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UNITED STATES BUREAU OF MINES

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DUST HAZARDS AND THEIR CONTROL IN MINING



BY

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DUST HAZARDS AND THEIR CONTROL IN MINING^{1/}

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By D. Harrington^{2/}
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Advocates of health and safety in mining have found themselves confronted in recent years with what might appear to be contradictory procedures with regard to dust occurrence in mines and what appear to be suitable methods or measures to give the mines and mine workers a maximum measure of protection against dust. A concerted and relatively effective drive has been made to introduce rock dust into bituminous and lignitic coal mines to prevent or limit explosion and fire disasters, while an equally determined effort has been and is now being made to curb rock dust or to eliminate it from air in metal mines to prevent or at least limit the occurrence of miners' consumption and other diseases. Both procedures are logical even though the efforts appear to be of an opposing nature.

While rock dusting has not been applied in coal mines nearly as universally or as effectively as could and should be done, nevertheless a careful analysis of the record of the past 10 years indicates that the amount of rock dusting that has been done has resulted in the saving of a minimum of 200 lives annually - certainly no small achievement. Largely but by no means wholly due to the use of rock dusting, the number of fatalities from explosions and fires in our coal mines in the last 4 years has been reduced more than 75 percent as compared with the 4-year period 1911-15, the first years of the existence of the United States Bureau of Mines, which was brought into existence in 1910 largely to try to do something about reducing the disgracefully high fatality occurrence from explosion disasters in our coal mines. Hence, rock dusting has been given at least a trial and has proved its effectiveness definitely.

The campaign to eliminate or at least to reduce the presence of rock dust in the air of metal mines has been by no means as sensational or as definitely successful as has that to introduce rock dust into bituminous and lignitic coal mines; this is due to the difference in the spectacular feature of the results of failure to apply the remedy in taking proper precautions as to air-borne dust in metal mines, as compared with failure in controlling coal-mine dust; failure in controlling dust in certain kinds of coal mines may cause scores of human beings to be hurled into eternity in a few seconds, while failure to handle metal-mine

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dust conditions adequately works its harm on single individuals and usually only after months or years of exposure. Notwithstanding this lack of spectacular action of air-borne rock dust, there is good reason to believe that since the beginning of the present century more underground workers in the United States have gone to their graves through the breathing of harmful dusts than have been sent there through the more sudden and spectacular instrumentality of explosions or fires. As with the coal-dust-explosion hazard, the remedies are readily available in connection with the other features of dust harmfulness (including breathing it), and organizations that really wish to avoid the various harmful effects of dust occurrence in mines can readily do it.

There are almost innumerable uncertainties connected with the harmfulness of dust, but dust is now generally believed to be detrimental to health through its effect on the throat, bronchial passages, lungs, stomach, and other internal organs as well as on the eyes, ears, nose, and other external organs and the skin covering the entire body. Many dusts (metal, mineral, and organic) are explosive, others fire spontaneously with more or less readiness under varying conditions, and practically all dusts have almost universally detrimental or so-called "nuisance" effects when they settle in the home, in the office, or on the external surfaces of buildings or on the roads, streets, or sidewalks; all of these facts (and almost innumerable others can be added) make dust one of the real scourges of present-day life, and certainly no sane person can deny that a most determined effort should be made to reduce dust or at least to confine it in such manner as to minimize its numerous harmful effects.

It now seems probable that the most harmful of the ordinary dusts to breathe is that of silica; but it must be emphasized that not even free silica (supposedly the most detrimental of the silica dusts) is harmful unless it is breathed in considerable quantities or concentrations and over extended periods of time; no human being ever lived any considerable span of years on this earth of ours without breathing silica dust (a large part being free silica), yet this does not mean that all of the people in the world now have or have had silicosis. In other words, the quantity of dust taken into the respiratory organs is a controlling factor in dust-respiratory harmfulness, and common sense indicates that the quantity of dust breathed is one of the dominant factors as to possible harmfulness to health from any kind of air-borne dust. What constitutes that quantity limit, no human being knows at this time, notwithstanding the fact that numerous so-called "threshold" limits are now being announced, some of them being embodied in State regulations or laws. Predicating dust-respiratory harmfulness on a sliding scale in proportion to the free-silica content of the dust is anything but logical; in the first place, no one knows whether a dust of 1 percent silica is or is not more harmful than a dust of 2 percent, 3 percent, or even 30 percent. Moreover, air with a certain number of dust particles per cubic foot with a silica content of 1 percent (or any other percentage) would probably be far more harmful to one person than to another or would be far more harmful to a person working at maximum capacity (as when on a contract basis) than to one on a day-pay basis, or more harmful to a person working in an atmosphere of 85° or 90° F. with

relative humidity 90 or 95 percent than to one working in an atmosphere of 60° F. with relative humidity around 60 percent. There are numerous other more or less similar contributing factors that make unworkable or futile the establishment of regulations as to the allowable number of dust particles on a sliding scale in proportion to silica content of the dust. In some industries, such as metal mining and tunneling, there may be as many different percentages of silica in the mine air as there are places working, and in many metal mines it is entirely unlikely that the percentage of silica in the air of a working place today will be at all like the percentage of silica in that same place tomorrow; to apply to most metal mines the sliding scale of allowable number of dust particles in the air in proportion to silica content would be utterly impossible of enforcement or fulfillment.

Much should be done to clarify numerous uncertainties as to air-dust harmfulness before it is attempted to establish more or less rigid air-dust standards by legal means.

At present there is definite lack of knowledge as to the size of air-borne dust likely to be harmful, and present-day so-called "standards of air dustiness" are built on numerous uncertain premises on this point alone. Different authorities find varying maximum and minimum sizes of dust in lungs of deceased silicotics ranging from as small as 0.2 micron to as large as 10 microns, and from this fact it is deduced that, as far as lung harm is concerned, the dust to be avoided is that from 2/10 to 5/10 micron, on the low side, to 6 or even as high as 10 microns, on the high side; this leaves much leeway, because an air-dust sample containing 10,000,000 particles (5/10 to 6 micron size) per cubic foot of air might easily have 30,000,000 particles 2/10 to 10 microns in size. Moreover, if the solution theory of dust harmfulness to the lungs is correct, there is the best of reasons to think that particles much smaller than 2/10 micron are very likely to be harmful. And to hold that the only harmful dust sizes are those found in the lungs is anything but good reasoning, because it is a certainty that dusts from 10 microns to 100 or more microns in size when floating in the air are drawn into the nostrils and other protective air passages, and if in large numbers soon clog these protective agencies and passages, giving practically free unobstructed entrance of the so-called "harmful" dusts (say 2/10 to 10 micron sizes) into the lungs to perform maximum injury. It does not seem to be logical to disregard these larger sizes entirely, as is now almost universally done in the so-called "dust standards" being considered and announced. Again, the present-day instruments and methods of sampling air-borne dust and making the determinations as to number of particles present are anything but accurate or definite, even when handled by technically trained experts; and methods or instruments applied to certain industrial conditions are wholly unsuited to others. A condition as to air dustiness found in one sample in a certain place is unlikely to be anything like another sample taken immediately afterwards in the same place and in the same manner; this is true where the sampling is done instantaneously by a grab method or over a period of several minutes. In other words, the technic as to quantity

particle determinations in air dustiness is by no means definite, accurate, fair, or dependable, not only as to conditions as between different plants but even as between different time periods in the same place in any one plant. With all of these as well as numerous other uncertainties as to air-borne dust, it seems to be a travesty on justice to try to embody in laws, and regulations having the force of law, rigid standards as to air dustiness; if quantity standards as to air-borne dust are made, they should certainly be labeled tentative; and the technic of taking the air samples and making the particle determinations should be very carefully outlined and enforced, otherwise much injustice can be inflicted through inexperience or the malice of the persons making the determinations.

The remedy for harm to health from dust in mines of today is chiefly twofold - use of water to "kill" the dust and use of ventilating current of fresh air to remove or dilute air dustiness where it is not feasible to "kill" the dust by water. In metal mines, no drilling of any kind should be allowed without simultaneous use of water, and the water should be under pressure and forced through the drill steel so as to "kill" the dust as it is being formed at the face of the drill hole. Many mines resist this practice because of expense of wet-drilling equipment and of placing and maintaining water lines and water at all working faces; miners resist because they hate to do anything they have not been accustomed to doing, because the use of water entails new responsibilities, and because the water tends to wet the clothing. Many other reasons are given by owners as well as by miners why wet drilling cannot be done, but in at least 9 out of 10 mines wet drilling can and should be insisted upon.

Blasting should be done after the working shift instead of during the shift, as it has been found that next to dry drilling blasting is the worst present-day producer of dust in air in sizes and concentrations likely to be harmful to those who breathe it. Moreover, there is good reason to suspect that the gases produced in blasting have a rather serious, harmful effect on those who breathe fine dusts, due to inflammation of the respiratory organs by the breathing of those gases even in relatively minute proportions. Various available adjuncts to blasting, such as water blasts or curtains, mist projectors, etc., as well as frequent wetting of the muck piles after blasting and of the face region before blasting are now required and utilized by careful mine operators, even when blasting is done at the end of the shift or on the off shift.

In coal mines, the mining machines should be equipped with water spray, and to be really effective the water should be piped to the face and be under pressure; here, again, the operator says it is impracticable, expensive, etc., but the answer is that water lines are being kept at working faces in extensive, up-to-date coal mines in several States and at a large number of faces in many metal mines, also. Water should be used on the drilling machines in metal mines and on the mining machines in coal mines, and if piped to the faces, can and should be used by the worker to wet down the broken rock or coal, together with surrounding walls, timber, floor, etc., where dust would otherwise accumulate; this is being done now in numerous mines in several States. It is due largely to the much better

ventilation of coal mines than of metal mines that coal miners are less afflicted by dust disease than are metal miners. It is also due to some extent to the better ventilation of coal mines that it is feasible to introduce rock dust into coal mines to prevent or limit explosions and fires and yet not unduly endanger the health of workers, because currents of fresh air remove floating particles of dust and few, if any, dusts that occur in coal or metal mines are harmful to health unless they are present fairly continuously in finely divided form and in large amounts in air breathed by workers through the working shift.

The general, although not universal, practice in some coal-mining regions (and a good health and safety practice) demands use of water at working faces to "kill" dust as it is being formed and rock dusting of the open parts of the mines away from the faces. Most mines rely very little on the use of water, and where rock dust is used the intent is to carry rock dusting virtually to the faces; this rock dusting to the face appears to be poor policy (unless water is unobtainable), as it introduces additional dust at the faces where about 95 percent of the dust in coal mines is formed, thus adding rock dust to the already coal-dust-impregnated air at working faces; this is likely ultimately to bring about a very serious health problem as well as to decrease visibility very greatly, as dust in the air of coal-mining places reduces visibility 50 or more percent - a decidedly dangerous factor from a safety viewpoint, even if one should disregard considerations as to health or as to dust explosibility. Moreover, cutting coal dry throws quantities of very fine coal dust into the air, which settles later on surrounding surfaces; blasting and shoveling also throw much fine dust into the air, later to settle on walls, timbers, roof, and floor; and if 1 or 2 percent of methane (explosive gas) is present, there must, in some cases, be 80 percent or more of rock dust (almost impossible to maintain) to prevent ignition of the coal dust of some of our coal mines.

CONCLUSION

This article treats only lightly of dust hazards and has been confined chiefly to dust explosibility and to respiratory disease and almost wholly to lung affections; it gives little or no consideration to the numerous ill effects on human organs other than the lungs due to breathing more or less insoluble dust, or the harm to other internal organs (stomach, liver, kidneys, etc.), or to the nose, throat, and bronchial tubes from breathing more or less soluble or so-called "poisonous" dusts; nor does it take into consideration the numerous hazards to human beings in the breathing of organic dusts, with accompanying hay fever and kindred ills. Moreover, numerous dusts, both organic and inorganic, have harmful influences of various kinds on eyes, ears, and other parts of the body, and on the skin from external contact; and some dusts cause harm to health by being absorbed through the skin. Hence, while pulmonary disease due to the breathing of air-borne dust is unquestionably of great present-day importance, its various ramifications (pneumoconiosis, silicosis, anthracosis, or these combined with tuberculosis), while vitally important, constitute by no means the only detrimental effect to human beings in coming in contact with dust, externally or internally.

A close analysis of the status of dust in industry (and in general life outside of industry also) indicates that numerous, one might almost say innumerable, uncertainties still exist as to specific features connected with dust harmfulness, and so numerous and far reaching are these uncertainties (only a few of which have been indicated in this paper) that almost the only definite fact now available is that dust is a menace and all kinds of it likely to come in contact with human beings should be reduced to a minimum or at least be held under positive control until such time as much well-planned, well-correlated research and investigative work (field and laboratory) has been done on almost every phase of the subject of dust, and much additional information has been obtained as to harmful as well as so-called "harmless" dusts.

Numerous clear-thinking persons who have made a minute, comparatively long-time study of dust harmfulness are now expressing the view that much remains unknown as to the health harm from dust, and that about the only safe procedure is to take all reasonable measures to reduce air dustiness where men must work or live. Philip Drinker, as chairman of a Committee on Preventive Engineering in connection with air dustiness, is quoted as follows in *Safety Engineering* for December 1936 (vol. 72, no. 6, p. 62):

There is no satisfactory medical answer at present to this question, but the engineer is making a bad mistake if he lets men breathe heavy dust concentrations of any material. If no other reason for dust control can be found, then one should read transcripts of some of the recent suits at common law, in which fantastic damages for alleged silicosis were granted to men who breathed dust containing little or no silica. The courts and compensation boards are not impressed with subtle distinctions between dusts with 10% and 40% quartz, especially when medical experts are reluctant to make definite statements as to the comparative significance of such differences.

It would be well to realize that men working in dusty trades suffer far more from respiratory troubles of all kinds than do men who work in clean air. The evidence that excessive dustiness of any kind is harmful is beyond argument.

The *Colliery Guardian*, probably the leading technical coal-mining magazine in Great Britain, had an editorial on "The Removal of Dust" in its issue of October 23, 1936 (vol. 153, no. 3956, p. 777), the introductory paragraphs reading:

The British Colliery Owners' Research Association has shown much wisdom in selecting for attack that front of the dust problem which is concerned with the causation of dust in mines and its dispersal. For the time being, the duty of ascertaining the character of the dusts that may be classed as dangerous to the worker must be left to the geologist and pathologist, and to the medical men the difficult questions involved in the treatment of the diseases arising from the inhalation of dust.

From the standpoint of those diseases, it is necessary, of course, to accept certain criteria which have been laid down by the pathologists and have been tentatively adopted by the law-givers, but the dust problem extends considerably beyond the limits of those definitions, for we may account dust as a nuisance irrespective of its influence upon health and as a predisposing cause of chest ailments, and it constitutes, as we all know, a grave danger to the mine worker on account of its explosive character. So that the mine manager is disposed to regard with favour any means within reason of reducing the quantity of dust in the workings, irrespective of its character, instead of attempting meticulous eliminations of the more dangerous elements.

These are sensible statements made by thinking people, and wise mine-operating officials of the present and of the future will be far less inclined to split hairs as to what constitutes a harmful dust and concentrate their faculties and abilities on the feasible methods of handling the dust hazard so it will be reduced to a minimum in the property and as applied to the employees. At present, the best procedure is to kill the dust, and it can be done.